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(54) Flowmeters.

(57) A flowmeter (FI) having a valve member (17), and a plunger (19) movable in response to fluid flow is characterised in that indicator means responsive to the position of the plunger (19) to give a reading of the rate of flow of fluid comprises a detector (39) responsive to the position of the plunger (19) to produce a signal proportional to the displacement of the plunger, a linearizer (59) having a read-only memory (ROM) programmed to compensate for non-linearities in the flow responsive displacement characteristics of the plunger reproduced in the detector output and so produce a linear output, and a display unit (41) for receiving the output of the linearizer and so provide an accurate reading of any rate of flow throughout the range of the flowmeter.

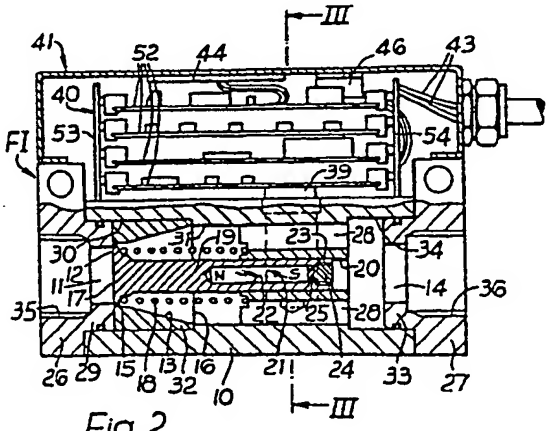


Fig. 2

EP 0 099 712 A2

FLOWMETERS

This invention relates to flowmeters of the type comprising a body, an inlet leading to the smaller end of a tapered passage in the body leading towards an outlet, an annular seating at the smaller end of the tapered passage and facing towards the larger end, a circular valve member, a spring urging the valve member towards contact with the seating, a plunger coaxial with the valve member and slidable in a bore in the body, and indicator means responsive to the position of the plunger to give a reading of the rate of flow of fluid through the tapered passage.

Preferably, there is no mechanical link between the plunger and the indicator means, so that this type of flowmeter is particularly suitable for high pressure fluids. It is therefore known to house at least one bar magnet in the plunger to move a pointer over a scale. Such a flowmeter is described in U.K. Patent Specification 1 201 441 and corresponding U.S. Patent Specification 3 626 756 as having a pair of bar magnets end-to-end in the plunger with the

adjacent poles of like polarity but spaced from each other, the pointer being made of ferromagnetic material and being disposed transversely of the plunger so as to be constrained by the like adjacent poles to move over the scale in accordance with movement of the plunger and magnets with the valve member. An improved form of flowmeter is described in U.K. Patent Application 8134799 (Publication No. 2 090 419A) as having one bar magnet axially adjustable in the plunger for adjustment of the zero position of the pointer, which is rotatable on an axis perpendicular to the axis of the plunger and laterally offset therefrom and is secured to a circular magnet having diametrically opposed poles, whereby the scale may be marked out over 180° or a substantial part thereof.

Flowmeters as just described, with pointers coupled magnetically to the plungers, suffer from a number of disavantages among which are that the position of the pointer of the scale may be such that it is difficult to read (especially if the flowmeter is in a difficultly accessible position, e.g., in a mine working), that the calibrated graduations

of the scale are non-uniform because the movement of the plunger is not linearly proportional to the rate of flow (particularly with the lower rates of flow), and that it is not possible or convenient to arrange for remote display of the reading.

One object of the invention is to provide a flowmeter of the type initially decribed without the disadvantages of those with pointers coupled magnetically to the plungers.

Another object of the invention is to provide a flowmeter capable of giving a digital read-out.

A further object is to provide a flowmeter also capable of being adapted to give a display of rate of flow and/or temperature and/or pressure.

Yet another object is to provide a flowmeter with a remote display or recording equipment.

A still further object is to provide a flowmeter also capable of being adapted to give a digital display of total flow within a period or from a specific time.

According to the present invention, a

flowmeter of the type initially described also comprises a detector responsive to the position of the plunger to produce a signal proportional to the displacement of the plunger, a linearizer having a read-only memory (ROM) programmed to compensate for non-linearities in the flow responsive displacement characteristics of the plunger reproduced in the detector output and so produce a linear output from the linearizer, and a display unit for receiving the output of the linearizer and so provide an accurate reading of any rate of flow throughout the range of the flowmeter.

The plunger may contain a bar magnet, in which case the detector consists of a Hall-effect integrated circuit, which produces a signal related to the position of the magnetic field of the bar magnet.

If, as is frequently the case, the signal output of the detector is dependent upon temperature, a signal conditioning amplifier is preferably provided, connected in circuit with a temperature sensing semi-conductor device adjacent the detector, the output of which device is used to alter the

gain and offset of the detector output to produce a signal which does not vary significantly with temperature.

The display unit may be attached to the body of the flowmeter (e.g. having a digital display incorporated in place of a pointer and scale, and with a Hall-effect integrated circuit incorporated in place of a circular magnet) and/or the display unit may be remote from the body of the flowmeter. The output from the linearizer may be used to drive an analogue or digital display and/or an interface to enable signals to be transmitted to remote monitoring or recording equipment.

A by-product of measuring the temperature for doing the compensation, by a signal conditioning amplifier, is that an ouput signal can be obtained of temperature. Alternatively, or in addition, a pressure transducer may be incorporated in the body of the flowmeter so that an output signal can be obtained for pressure.

The ROM of the linearizer requires the analogue signal from the signal conditioning amplifier to be converted to digital form. The digital output of the linearizer is ready

for a digital display unit, but it may be converted to an analogue form by means of a digital to analogue converter, which may be boosted by a voltage or current driver, before being fed to an analogue display.

The remote display unit may (in addition to displaying flow, or temperature and/or pressure) process the signals to indicate total flow within a period or from a specific time.

A number of embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of one embodiment of flowmeter in accordance with the invention, with an integral digital display unit;

Figure 2 is a longitudinal section of the flowmeter of Figure 1;

Figure 3 is a section from the line III-III of Figure 2;

Figure 4 is a perspective view of another embodiment of flowmeter in accordance with the invention, with a remote digital display unit;

Figure 5 is a longitudinal section of the flowmeter of Figure 4;

Figure 6 corresponds to Figure 1 but shows an integral analogue display unit;

Figure 7 corresponds to part of Figure 4 but shows an analogue display in place of one of the digital displays.

Figure 8 is a block circuit diagram for a flowmeter with an integral display unit; and

Figures 9A, 9B are block circuit diagrams for a flowmeter with a remote display unit.

The flowmeter FI shown in Figures 1 to 3 comprises a body 10, an inlet 11 leading to a smaller diameter end 12 of a tapered passage 13 in the body leading towards an outlet 14, an annular seating 15 at the smaller end of the tapered passage and facing towards the larger end 16 of the tapered passage, a circular valve member 17, a spring 18 urging the valve member towards contact with the seating, a plunger 19 coaxial with the valve member and slidable in a bore 20 in the body, a bar magnet 21 housed in a coaxial bore 22 in the plunger, a screwthread 23 in the bore 22,

a screw 24 mating with the screwthread and a resilient packing member 25 between the screw and the adjacent end of the magnet.

The inlet 11 and the outlet 14 are coaxial with the valve member 17 and plunger 19 and are provided in respective end caps 26, 27 bolted to respective ends of the body 10, with longitudinal (non-axial) bores 28 through the body communicating the larger end 16 of the tapered passgage 13 with the outlet 14. The inlet end cap 26 has a tubular spigot 29 sealed in an enlargement 30 of a counterbore 31 of the axial bore 20 in which the plunger 19 slides, the enlargement 30 of the counterbore 31 also housing a cylindrical insert 32 in which is provided the tapered passage 13, which insert 32 is interchangeable. The spigot 29 of the inlet end cap 26 also provides the seating 15 round the inlet 11. The outlet end cap 27 has a tubular spigot 33 sealed in a chamber 34 in the body 10 into which the longitudinal (non-axial) bores 28 discharge and which is also a counterbore of the axial bore 20 in which the plunger slides. The end caps 26, 27 are provided with screwthreaded counterbores 35,

36 to enable the flowmeter to be connected in a pipeline (not shown) and are secured to the body 10 by screws 37.

The body 10 also has a blind bore 38 housing a detector 39 consisting of a Hall-effect integrated circuit (hereinafter referred to as "the magnetic detector 39"), which produces a signal related to the position of the magnetic field of the bar magnet 21 and, therefore, related to the position of the plunger 19 and proportional to the displacement of the plunger. The signal from the magnetic detector 39 is fed to an electronic module 40 within a display unit 41 attached to the body 10 of the flowmeter FI by means of screws 42. The module 40 has leads 43 from a 12V/24V D.C. power supply (not shown) and is connected to a liquid crystal display (LCD) 44 having a four-digit display capable of registering from 0 to 1999 relative to rate of flow through the flowmeter. The block circuit diagram is shown in Figure 8 and will be described presently. Encapsulated with the detector 39 is a temperature sensing semi-conductor device 45, and a button switch 46 enables the display 44 to be switched from

rate of flow to temperature for as long as the button is depressed.

In Figures 4 and 5 like reference numerals represent like parts to those in Figures 1 to 3, but the flowmeter FR in Figures 4 and 5 has a remote display unit RD and the electronic module 40 is housed in a simple casing 47 attached to the body 10 of the flowmeter FR by means of screws 42. In addition to the leads 43 from a 12V/24V D.C. power source (not shown) there are leads 48 to a terminal block 49 in the remote display unit RD, from which terminal block leads (not shown) connect with a four-digit liquid crystal display 44 and button switch 46 (serving as in the integral display unit 41), and also with an eight-digit liquid crystal display 50 for indicating total flow (within a period or from a specific time) and a button switch 51 for re-setting the display 50 to zero.

In Figures 6 and 7 an analogue display 44' is shown in place of the digital display 44 in the integral display unit 41 and in the remote display unit RD respectively.

The electronic module 40 consists of

four printed circuit boards 52 carrying various electronic components and their interconnections, and the printed circuit boards are interconnected by bus-bars 53 and 54, but the circuit diagrams for the flowmeters FI and FR (with remote display unit RD) are shown as block diagrams in Figure and Figures 9A, 9B respectively.

In Figures 8 and 9A the signal from the magnetic detector 39 is fed to a signal conditioning amplifier 55 connected in circuit with the temperature detector 45 and having zero and span controls 56, 57 respectively. The conditioned signal is fed through an analogue/digital converter 58 to a linearizer 59 having a read-only memory (ROM) programmed to compensate for non-linearities in the flow responsive displacement characteristics of the plunger 19 reproduced in the magnetic detector output and so produce a linear output, which is fed through an output module 60, either directly to the digital display 44 of the integral display unit 41 of the flowmeter FI as shown in Figure 8, or to the remote display unit RD which, as shown in Figure 9B, has an input amplifier 61 with outputs to the four-

digit display 44 and to the eight-digit display 50 through a totaliser 62 having the reset switch 51. In Figure 8 the selector switch 46 enables a signal from the temperature detector 45 to be temporarily directed through the output module 60 in the flowmeter FI with integral display unit 41 to show the temperature momentarily on the four-digit display 44, which otherwise shows continuously the rate of flow, while in Figure 9B the selector switch 46 enables the signal from the temperature detector 45 to be temporarily directed through an analogue/digital converter 63 of the remote display unit RD for the flowmeter FR, again to show the temperature momentarily on the four-digit display 44.

Figure 8 also indicates the inclusion of an optional pressure transducer 64 (the position of which is indicated in Figure 3) with a selector switch 65 enabling a signal from the pressure transducer to be temporarily directed through the output module 60 in the flowmeter FI with integral display unit to show the pressure momentarily on the four-digit display 44. Furthermore, Figure 8 also

indicates the possible alternative, or addition, of an analogue display 44' (see also Figure 6) having an output module 60' receiving the output from the linearizer 59 through a digital/analogue converter 66 and also receiving temporarily a signal from the temperature sensor 45 or the pressure transducer 64 upon temporarily depressing the switch 46' or the switch 65'.

Figure 9B likewise indicates the possible alternative, or addition, of an analogue display 44' (see also Figure 7) having an input amplifier 61' receiving the output from the output module 60 of Figure 9A through a digital/analogue converter 67 and also receiving temporarily a signal from the temperature sensor 45 upon temporarily depressing the switch 46'. A pressure transducer is not indicated in Figure 9A but could be incorporated in similar manner to that shown in Figure 8 and with appropriate connections and switches in Figure 9B.

CLAIMS

1. A flowmeter (FI or FR) comprising a body (10), an inlet (11) leading to a smaller end (12) of a tapered passage (13) in the body leading towards an outlet (14), an annular seating (15) at the smaller end of the tapered passage and facing towards the larger end (16) of the tapered passage, a circular valve member (17), a spring (18) urging the valve member towards contact with the seating (15), a plunger (19) coaxial with the valve member (17) and slidable in a bore (20) in the body (1), characterised in that indicator means responsive to the position of the plunger (19) to give a reading of the rate of flow of fluid through the tapered passage (13) comprises a detector (39) responsive to the position of the plunger (19) to produce a signal proportional to the displacement of the plunger, a linearizer (59) having a read-only memory (ROM) programmed to compensate for non-linearities in the flow responsive displacement characteristics of the plunger reproduced in the detector output and so produce a linear output, and a display unit (41 or RD) for receiving the output of the.

linearizer and so provide an accurate reading of any rate of flow throughout the range of the flowmeter.

2. A flowmeter as in Claim 1, characterised in that the plunger (19) contains a bar magnet (21) and in that the detector (39) consists of a Hall-effect integrated circuit, which produces a signal related to the position of the magnetic field of the bar magnet.

3. A flowmeter as in Claim 1 or Claim 2, characterised in that a signal conditioning amplifier (55) is provided, which is connected in circuit with a temperature sensing semiconductor device (45) adjacent the detector, the output of which device is used to alter the gain and offset of the detector output to produce a signal which does not vary significantly with temperature.

4. A flowmeter as in any one of Claims 1 to 3, characterised in that the display unit (41) is attached to the body (10) of the flowmeter (FI).

5. A flowmeter as in any one of Claims 1 to 3, characterised in that the display unit (RD) is remote from the body (10).

of the flowmeter (FR).

6. A flowmeter as in Claim 4 or Claim 5, characterised in that the display unit (41 or RD) has a digital display (44).

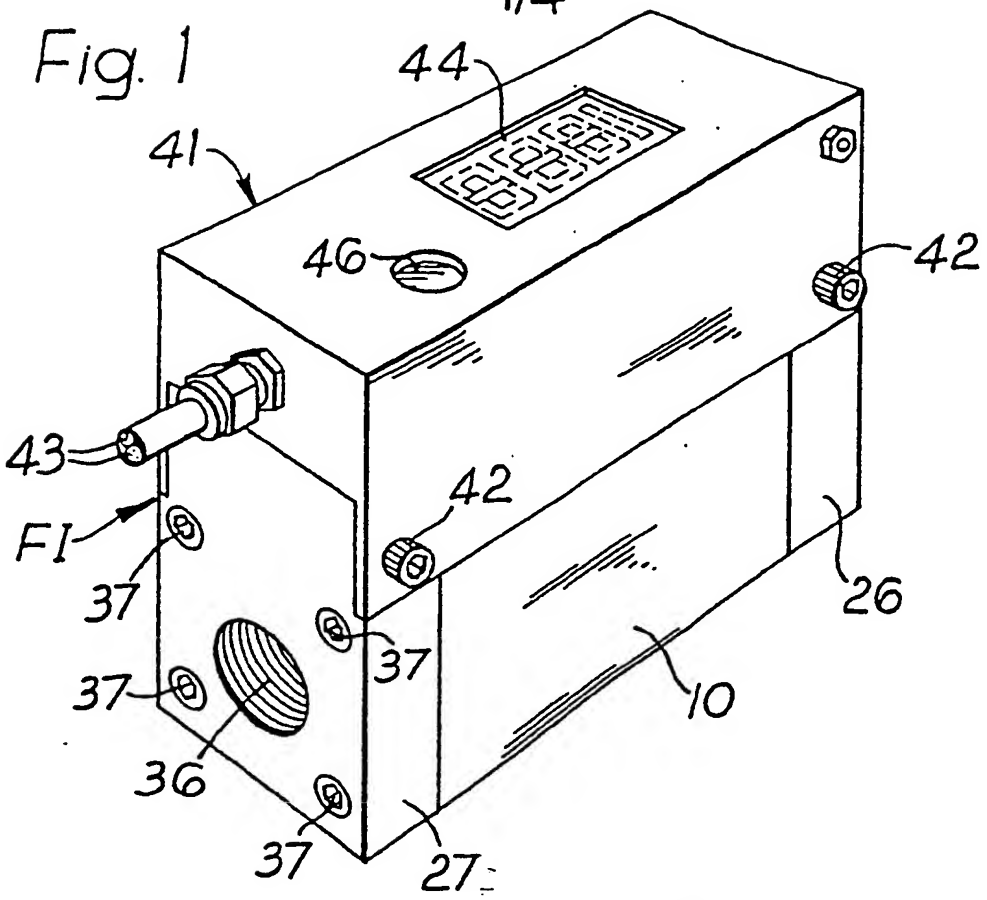
7. A flowmeter as in Claim 4 or Claim 5, characterised in that the display unit (41 or RD) has an analogue display (44').

8. A flowmeter as in Claim 3, characterised in that a switch (46) is provided for temporarily directing the signal from the temperature detector (45) to the display unit (41 or RD).

9. A flowmeter as in any one of Claims 1 to 8, characterised in that a pressure transducer (649 is incorporated in the body of the flowmeter so that an output signal can be obtained for pressure.

10. A flowmeter as in Claim 5, characterised in that the remote display unit (RD) is provided with a totalizer (63) with a digital display (50) to indicate total flow within a period or from a specific time.

Fig. 1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43
42
FI
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37
36
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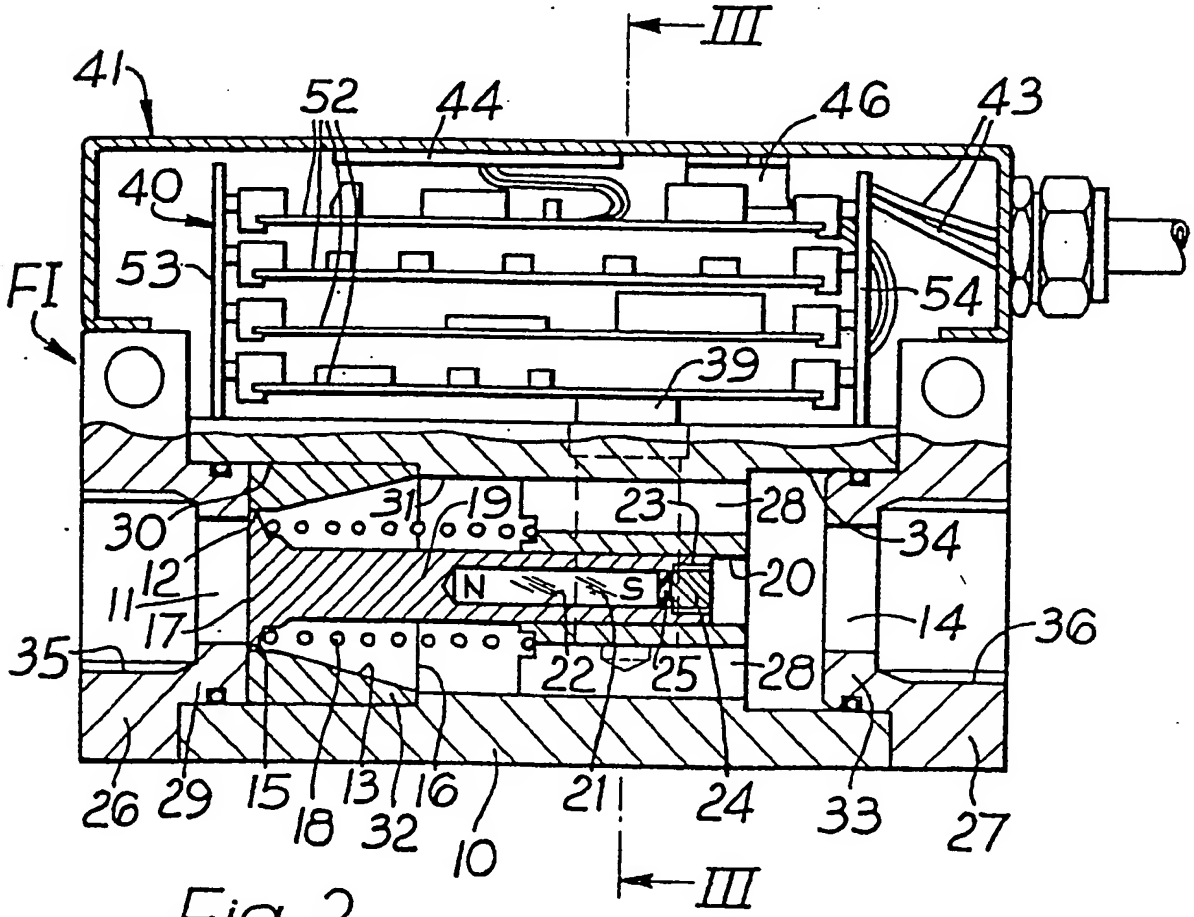
27
26
10


III
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FI
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31
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12
11
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S
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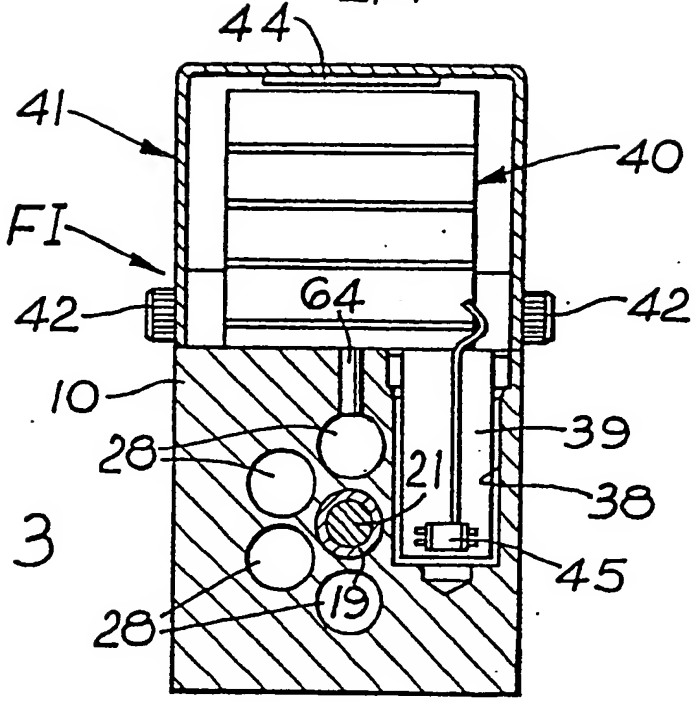
27
III

Fig. 2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FI
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64
42
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39
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21
38
45
28
19

Fig. 3

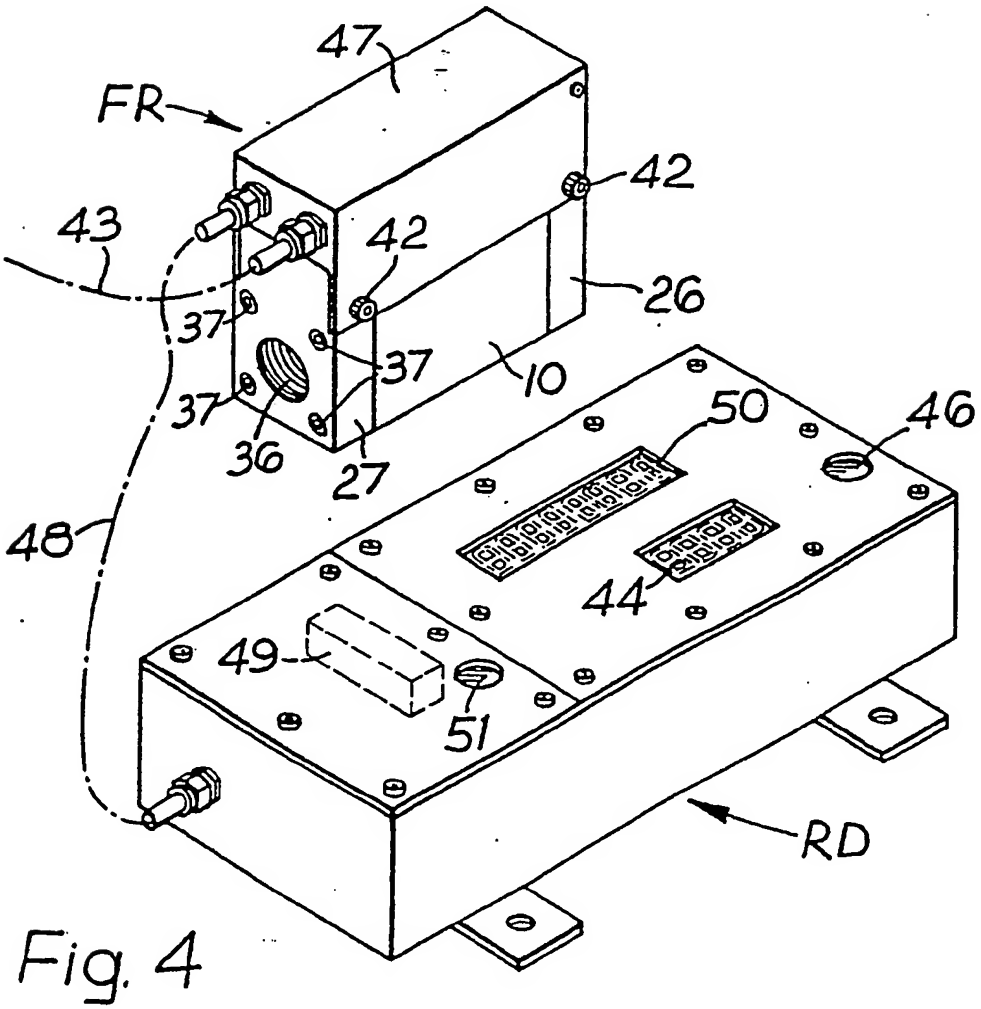
47
FR
42
43
42
26
37
37
10
37
36
27
50
46
48
44
49
51
RD

Fig. 4

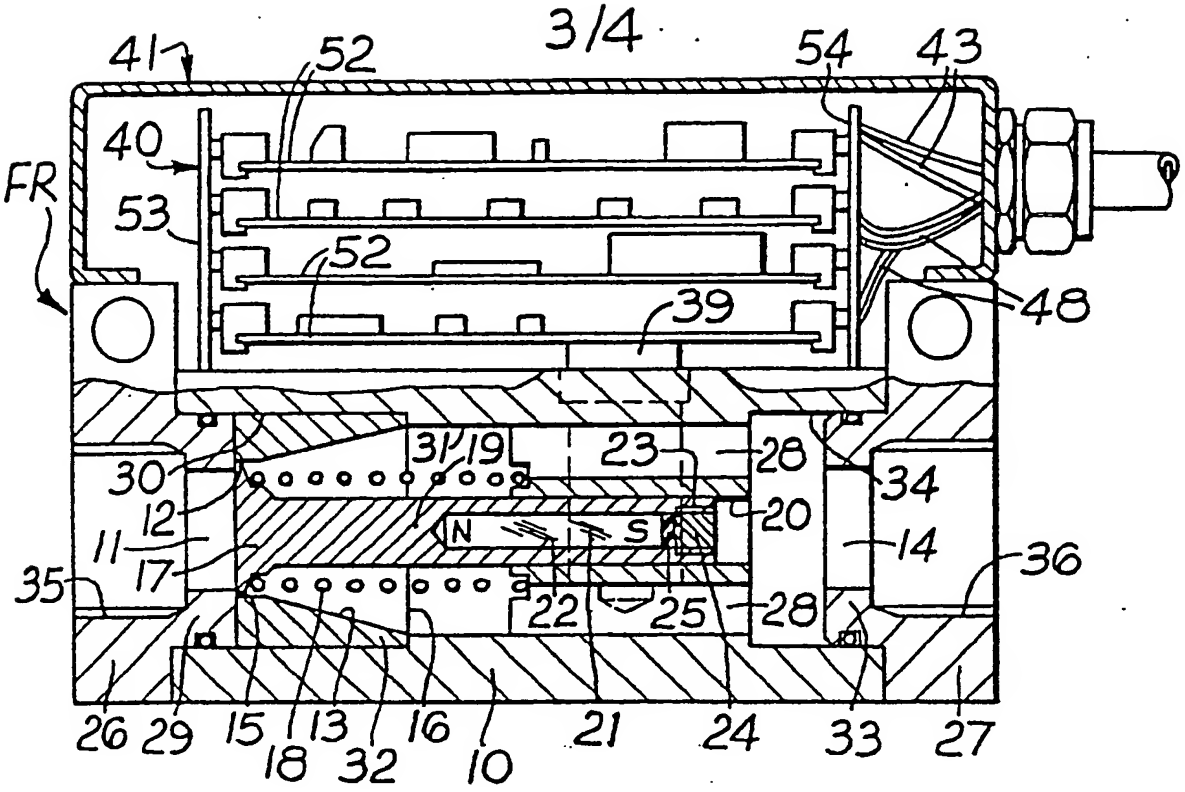

Fig. 5

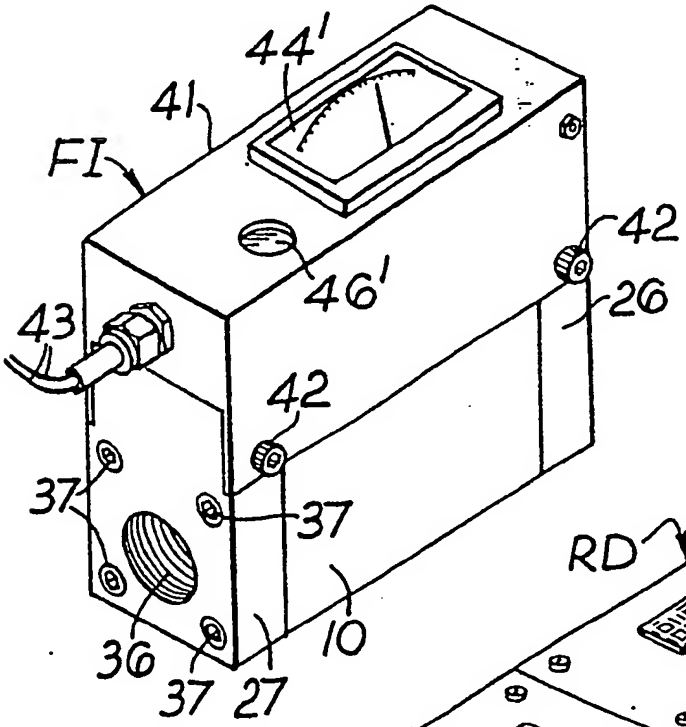

Fig. 6

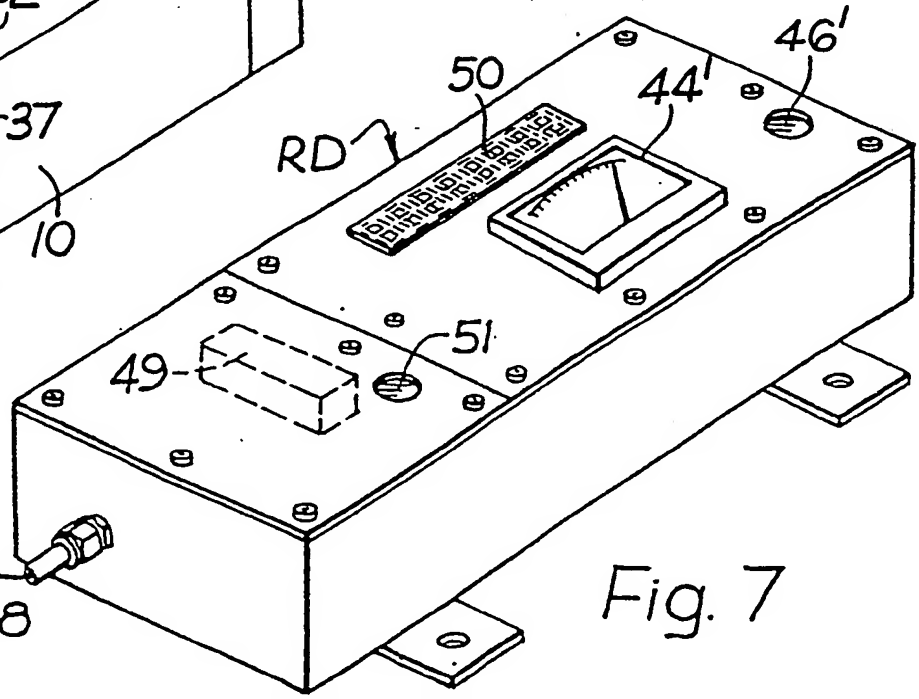

Fig. 7

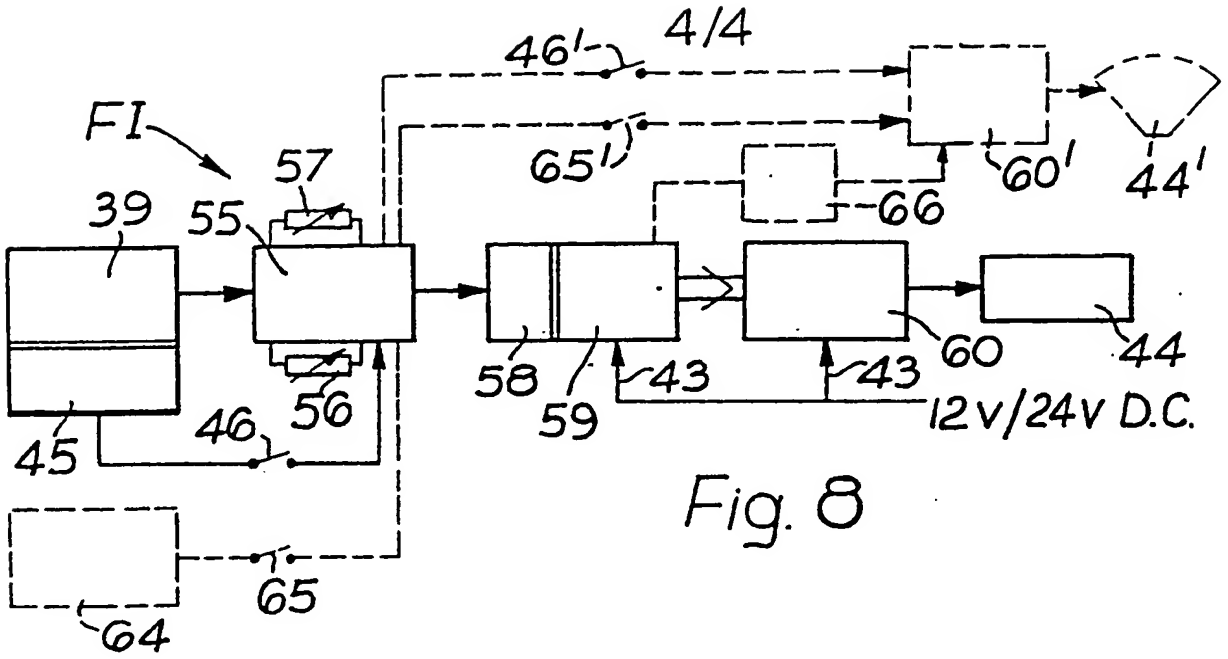

Fig. 8

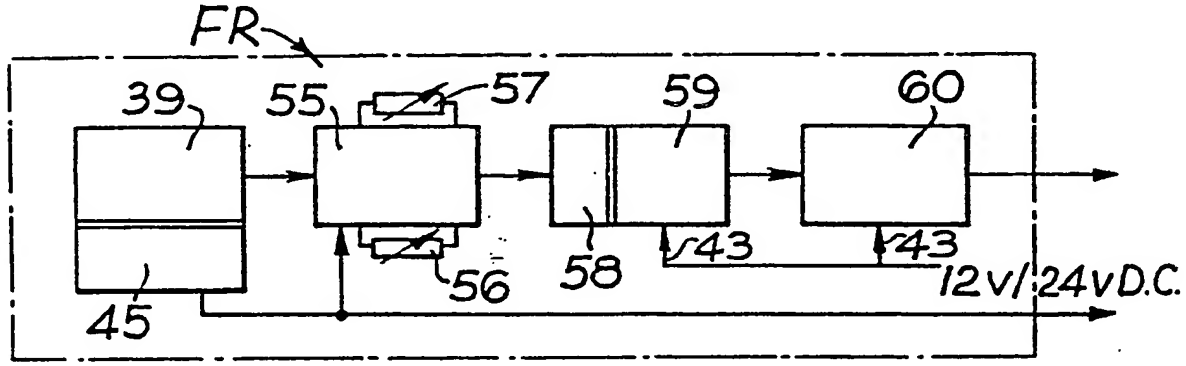

Fig. 9A

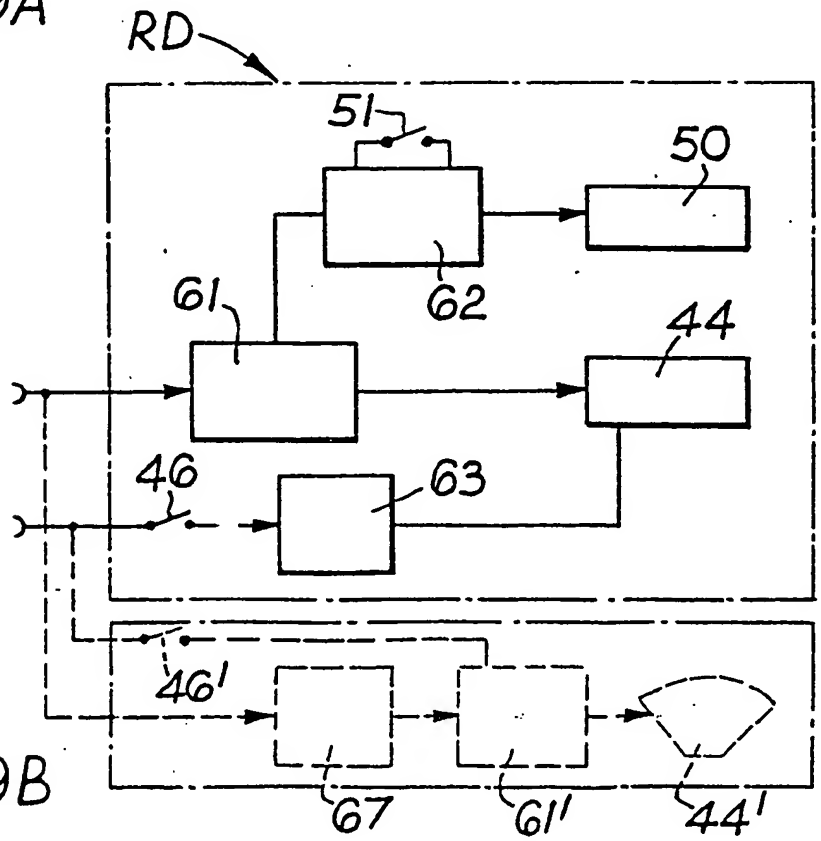

Fig. 9B

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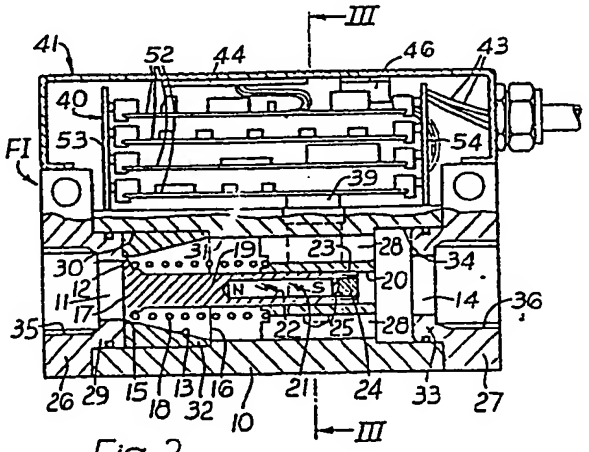

Fig. 2

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EUROPEAN SEARCH REPORT

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Application number

EP 83 30 4006

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Y	TECHNISCHES MESSEN, vol. 49, no. 4, April 1982, pages 137-140, Oldenbourg Verlag, Munich, DE; F. ARNOLDS et al.: "Schwebekörper-Durchflussmesser mit Mikrocomputer" * page 138, left-hand column *	1	
A	FR-A-2 155 303 (G.J. GRIFFITH) * figures 1-4; page 1, lines 22-26; page 2, line 28 - page 5, line 23 *	2	
A	MICROELECTRONICS JOURNAL, vol. 12, no. 6, November/December 1981, pages 24-29, Mackintosh Publications Ltd., Luton, GB; G.S. RANDHAWA: "Monolithic integrated Hall devices in silicon circuits" * whole document *	2	TECHNICAL FIELDS SEARCHED (Int. Cl. ³) G 01 F 1/26 G 01 F 1/24 G 01 F 1/22 G 01 F 15/06 G 01 F 15/075 H 01 L 27/22 G 01 K 13/02 G 01 F 1/37
A	US-A-3 745 827 (P.E. SWANSON et al.) * abstract; figure 4; column 2, line 59 - column 3, line 18; column 6, line 50 - column 8, line 30 *	3	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26-09-1984	NUIJTEN E.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A	DE-C- 664 606 (ROTA APPARATE- UND MASCHINENBAU FELIX MEYER KG IN AACHEN) * figure 1 *	5	
A	DE-A-2 815 664 (ARNOLDS et al.) * figures 1,2 *	7,6	
A	US-A-3 354 716 (D. WIEBE et al.) * figures 1A,1B, abstract; column 3, lines 1-15 *	8,9	
A	US-A-4 206 643 (H.H. PHILLIPS et al.) * abstract; figure 1; column 3, lines 33-38 *	5-7,10	
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

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